AFRL-SR-BL-TR-98-

0081

**REPORT DOCUMENTATION PAGE**



| 1. AGENCY USE ONLY *(Leave blank)* | 2. REPORT DATE | 3. REPORT TYPE AND DATES COVERED |
|---|---|---|
| | 12 Dec 97 | Final Tech Report, 01 Jul 96 - 30 Jun 97 |

**4. TITLE AND SUBTITLE**
Application of Geometric and Physical Invariants to Object Recognition

**5. FUNDING NUMBERS**
F49620-96-1-0355

**6. AUTHOR(S)**
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**8. PERFORMING ORGANIZATION REPORT NUMBER**

**9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)**
AFOSR/NM
110 Duncan Avenue Suite B115
Bolling AFB DC 20332-8050

**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**

**11. SUPPLEMENTARY NOTES**

**12a. DISTRIBUTION AVAILABILITY STATEMENT**
Distribution Unlimited.

**12b. DISTRIBUTION CODE**

**13. ABSTRACT** *(Maximum 200 words)*

The project was a continuation of a previous one, entitled "Geometric Invariants in Object Recognition". We have developed and applied new ideas within the framework of the concepts used in the earlier grant. We list here some of the publications that have resulted from this continuation grant along with representative abstracts.

DTIC QUALITY INSPECTED 2

19980129 044

**14. SUBJECT TERMS**
Distributed systems

**15. NUMBER OF PAGES**
2

**16. PRICE CODE**

| 17. SECURITY CLASSIFICATION OF REPORT | 18. SECURITY CLASSIFICATION OF THIS PAGE | 19. SECURITY CLASSIFICATION OF ABSTRACT | 20. LIMITATION OF ABSTRACT |
|---|---|---|---|
| Unclassified | Unclassified | Unclassified | UL |

Standard Form 298 (Rev. 2-89) (EG)
Prescribed by ANSI Std. 239.18
Designed using Perform Pro, WHS/DIOR, Oct 94

Final Report

# Application of Geometric and Physical Invariants to Object Recognition

Award # F49620-96-1-0355

Isaac Weiss

**Abstract**

The project was a continuation of a previous one, entitled "Geometric Invariants in Object Recognition". We have developed and applied new ideas within the framework of the concepts used in the earlier grant. We list here some of the publications that have resulted from this continuation grant along with representative abstracts.

## Journal Publications

- Applying Algebraic and Differential Invariants to Logo Recognition (with D. Doermann and E. Rivlin), *Machine Vision and Applications*, **9**, 73–86, 1996.
- Recognizing Objects Using Deformation Invariants (with E. Rivlin), *Computer Vision and Image Understanding*, **65**:1, 95–108, 1997.

**Abstract:** We study invariance to transformations having two components: 1) An arbitrary large affine transformation. This approximates a viewpoint change. 2) A small, but otherwise general, non-linear deformation. Such a deformation can arise from several sources, including change in the object itself. For instance, we want to recognize an apple even if individual apples are slightly different from each other. While there are no true invariants in this case, we show that affine invariants are quasi-invariants of these quasi-affine transformations. This is true for both global and local invariants. The method was applied to a set of real images.

- The Geometry of Visual Space (with Z. Pizlo and A. Rosenfeld), *Computer Vision and Image Understanding*, **65**:3, 425–433, 1997.

- Visual Space: Mathematics, Engineering, and Science (with Z. Pizlo and A. Rosenfeld), *Computer Vision and Image Understanding*, **65**:3, 450–454, 1997.
- Model-based Recognition of 3D Curves from One View. *Journal of Mathematical Imaging and Vision*, in press, 1997.

**Abstract:** It is well known that there are no geometric invariants of a projection from 3D to 2D. However, given some modeling assumptions about the 3D object, such invariants can be found. The modeling assumptions should be sufficiently strong to enable us to find such invariants, but not stronger than necessary. In this paper we find such modeling assumptions for general 3D curves under affine projection. We show, for example, that if one of the two affine curvatures is known along the 3D curve, the other can be found from the curve's 2D image. We can also derive the point correspondence between the curve and its image. We also deal with point sets and direction vectors.

- Scale Space Invariants for Recognition (with A. Bruckstein and E. Rivlin), *Image and Vision Computing*, **15**:5, 335–344, 1997.

**Abstract:** In this paper we discuss a new approach to invariant signatures for recognizing curves under viewing distortions and partial occlusion. The approach is intended to overcome the ill-posed problem of finding derivatives, on which local invariants usually depend. The basic idea is to use invariant finite differences, with a scale parameter that determines the size of the differencing interval. The scale parameter is allowed to vary so that we obtain a "scale space"-like invariant representation of the curve, with larger difference intervals corresponding to larger, coarser scales. In this new representation, each traditional local invariant is replaced by a scale-dependent range of invariants. Thus, instead of invariant signature curves we obtain invariant signature surfaces in a 3-D invariant "scale space".